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A BASELINE STUDY ON CORAL REEF FISHES IN THE MARINE PROTECTED AREAS IN SOUTHERN CEBU, PHILIPPINES

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ABSTRACT

Marine protected areas in the sampling sites have been established 8-13 years ago. This study was conducted to have a baseline information on the diversity, density and biomass of coral reef fishes inside and outside the five marine protected areas (MPAs) of Casay, Argao; Cawayan, Dalaguete; Daan-Lungsod Guiwang, Alcoy; North Granada, Boljoon and Sta. Cruz, Ronda (Control). Coral reef fishes in the MPAs were identified using Fish Visual Census Method. Results of the t-test showed that the mean diversity (fish species/250m^2) of target and non-target fish species found in areas inside and outside the MPAs were significantly different. In terms of target species, the inside and outside density showed no significant difference. Similarly, density (ind./1,000m^2) of non-target species inside and outside also showed no significant difference. This is an indication that fish density inside and outside the MPAs were more or less of the same condition. The mean biomass (kg/1,000m^2) of target species inside and outside the MPAs showed a significant difference in contrast with non-target species inside and outside the MPAs which showed a no significant difference. Higher biomass of target fish species belonging to family Caesonidae (fusiliers) and Scaridae (parrotfishes) were commonly observed inside the MPAs. Results showed that fish species were more diverse with higher density and biomass inside the MPAs than the outside area. However, fish diversity and density were contributed mostly by non-target species. Hence, the need for a long-term protection and a well-managed MPA to improve fish population in terms of diversity, density and biomass specifically, target fish species.

Keywords: marine sanctuary, target and non-target fishes, diversity, density, biomass

INTRODUCTION

Coral reef fishes form one of the most diverse community associations of animals in nature. A nearshore fish fauna in excess of 2,000 species is known from the Philippines, the generally acknowledged center of diversity of coral reef fishes. (Ogden and Quinn, 1984). Reef fished evolved in shallow tropical seas in the vicinity of coral reefs within 20 million years. Coral reef fishes are highly diverse, both in number of species and in range of forms (Alcala, 2001).

Marine protected areas (MPAs) are valuable tools in protecting coral reef habitats and managing near-shore fisheries and play important roles in the overall conservation of marine biodiversity (Green et al., 2011). MPAs positive impacts have long been studied since its establishment in the year 1970s and have become popular tools for fishery management and biodiversity conservation in increasing fish population not only in the Philippines, but also worldwide. MPAs can achieve protection of particular, well-defined areas and critical habitats

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(Agardy, 1997). When properly designed and well managed, an MPA can meet various marine and coastal conservation needs by preserving habitat and important species and protecting specific areas. Coral reef fisheries, in particular, can be effectively managed through implementation of "no-take" areas on reefs (Roberts and Polunin, 1993).

Studies have proven the benefits of a well-protected marine sanctuary including increase in the diversity, density and biomass of coral reef fish and other macro-invertebrates. There are many documented examples where fished species have benefited from reserve establishment, in particular through increases in mean size and abundance (for reviews, see Roberts and Polunin, 1991; Dugan and Davis, 1993; Rowley, 1994; Bohnsack, 1998; Halpern, 2003). Sometimes, biological responses (abundance, density, biomass, average size, and diversity of organisms) either consistently increased within the reserve over time (Russ and Alcala, 1996), showed little change over time (Denny and Babcock, 2004), or initially rose but then fell back to original levels (Dufour, Jouvenel and Galzin, 1995).

The first marine park in Cebu Province was established around Sumilon Island in Oslob, Cebu by Silliman University in 1973. It was established for marine biological studies and research and to regulate fishing and gathering of marine products within the island. Studies conducted in Sumilon demonstrated that protection increased and maintained fish abundance and biomass within MPAs which resulted in the export of adult fish to areas outside the MPAs. The effect of protection of the marine park has served a model of coral reef fishery management in the Philippines, resulting in the establishment of several marine reserves in the Philippines (Alcala, 2001).

There are 120 MPAs in Cebu Province; however, only 50 percent of these are functional. Moreover, half of these MPAs are not well-managed because of weak governance and law enforcement, lack of financial support, insufficient logistical support from the government, political factions and lack of support and cooperation from the community (Alcala, Bucol and Nillos, 2008). Even with the presence of MPAs, people still do not fully see its effect hence, some continue to engage on illegal fishing activities which considerably reduced reef fish population.

There is, therefore, a need to conduct a baseline study to find out if there is a significant difference on the inside and outside of the five (5) MPAs in terms of fish diversity, density and biomass.

Result of this study would serve as a guide for LGUs in the management/conservation of their existing marine resources.

MATERIALS AND METHODS

Site Description

The five (5) marine protected sites chosen for this study are located in the southern part of Cebu. These included Argao, Dalaguete, Alcoy, Boljoon and Ronda (Figure 1) with varying sizes and legal bases (Table 1). The sites were chosen since these are under the Integrated Coastal

Resource Management Project (ICRMP) covered municipalities and were considered and recommended by their respective local government units as ICRM's priority MPAs.

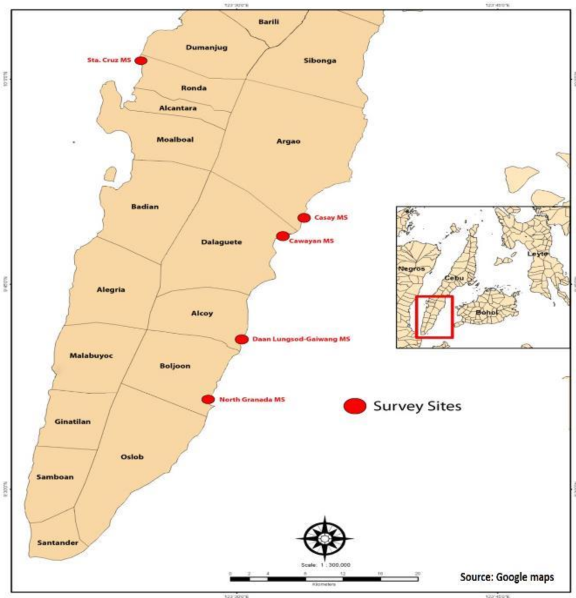

Figure 1. Map of Cebu Province Showing the Locations of the Five (5)MPAs as Survey Sites

Table 1. Site Description of the Five (5) MPAs (Alcala, Bucol and Nillos, 2008).

MPA site	Area (ha)	Year established	Legal basis
Casay MPA, Argao	11	2003	Mun. Ord. No. 65 s. 2003
Cawayan Marine Park and Sanctuary, Dalaguete	10	2006	Mun. Ord. No. 2006-145
Daan-Lungsod Guiwang MPA, Alcoy	22.71	2002	Mun. Ord. No. 19 s. 2002
North Granada MPA, Bojoon	9.35	2001	Mun. Ord. No. 04 s. of 2001
Sta. Cruz MPA, Ronda	9.2	2002	Mun. Ord. No. 89, s. of 2002

Conduct of the Assessment

Communication letters were sent to the local government units informing them of the conduct of the study. The research team scheduled a courtesy call with the local and barangay executives and conducted reconnaissance survey of the sites prior to the actual conduct of the research. Surveys were then conducted by a team from Cebu Technological University–

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Integrated Coastal Resource Management Center (CTU-ICRM), Department of Environment and Natural Resources (DENR), Bureau of Fisheries and Aquatic Resources (BFAR) and Sangkalikasan Producers Cooperative, a non-profit organization active in marine conservation, using Self Contained Underwater Breathing Apparatus (SCUBA). Mapping of the boundary coordinates of the MPAs were obtained using a hand-held Global Positioning System (GPS).

Individual status of the reef fish communities within and outside the MPAs was assessed following the Fish Visual Census (FVC) method of English, Wilkinson and Baker (1997).

At least four replicates of a 50-meter transect line were laid out parallel to the shore. Individuals were counted to estimate fish abundance from the actual fish count encountered along the 50 transect line and within 2.5 m on each side.

Species were identified to the lowest taxonomy possible, counted and their sizes (standard length) estimated in situ to the nearest cm (English, Wilkinson and Baker, 1997). Fish identification followed that of Allen et al. (2003) and Fish Base (2004). Only diurnal fish species were surveyed. Fish species were classified as “target” if they were caught deliberately by fishers and as “non-target” if they were not (Mosquera et al., 2000). Target species according to the fishers, are those caught and favored by the fishermen for their high commercial value and commonly sold in markets for food consumption. While non-target species are those species caught for aquarium trade and has an ecological value.

Reef fish status was determined based on fish diversity, abundance and fish biomass using the categories described by Hilomen, Nañola, and Dantis (2000) and Nañola et al. (2006) where values were computed from a 1000m^2 (Table 2). Thus, our values were extrapolated from the 250m^2 sampling area to 1000m^2 to be able to use the fish species diversity category. Fish biomass was calculated using the formula:

$$W=a*L^b$$

Where:

W= weight in (g)
a= the multiplying factor
L= the estimated length (cm)
b= the exponent (b<1)

The specific constants *a* and *b* used in this study were determined following the methods by Letourneur, Kulbicki and Labrosse (1998) and through Fish Base (2004). For species where no constants exist, the known constants for the closest relative within the same body type were used.

Data were analyzed using descriptive statistics. The *t*-test was run to determine significant difference between the areas inside and outside the MPAs in terms of fish diversity, density and biomass.

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Table 2. Categories of Sites According to Fish Diversity and Abundance (adapted from Hilomen, Nañola, and Dantis, 2000).

Fish Species Diversity (species/1000m^2)				
Very Poor	Poor	Moderate	High	Very High
0-26	27-47	48-74	76-100	>100
Fish Density (ind./1,000m^2)				
Very Poor	Poor	Moderate	High	Very High
0 - 201	202 - 676	677 - 2,267	2,268 - 7,592	>7,592

Table 3. Categories of Sites According to Fish Biomass (adapted from Nañola et al., 2006)

Fish Biomass (MT/km^2)				
Very Low	Low	Medium	High	Very High
<5	6-10	11-20	21-40	>41

RESULTS AND DISCUSSION

Reef fish status of the MPAs were determined based on fish diversity expressed as (mean number of fish species/250m^2), fish density expressed as (ind./1,000m^2) and fish biomass expressed as (kg/1,000m^2).

Fish Diversity

Fish diversity, measured in terms of species richness and density of the fishes on a reef, give a good indication of reef health (Koh et al., 2002). Results showed that the mean number of target and non-target species in the four (4) MPAs (excluding Casay) found in areas inside and outside the MPAS was significantly different ($t(5.48) = 0.0015$, $p<.05$ and ($t(4.15) = 0.0060$, $p<.05$) respectively.

Among the four (4) MPAs, North Granada had the most diverse target species inside the MPA with a mean of 14 target species composed mainly of surgeon fishes (Acanthuridae), fusiliers (Caesionidae) and parrot fishes (Scaridae) followed by Daan-Lungsod Guiwang with 13 and

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Cawayan with 12 species (Figure 2).

Based on Hilomen's classification, diversity of target species were categorized as poor to moderate while non-target species were moderate to high in condition inside the MPAs (Table 4). Diversity of all fish species inside the MPAs was very high; however, these fishes are mostly composed of non-target species.

It was observed that target and non-target fish species in all MPAs were more diverse inside than outside the MPAs. However, non-target species were more diverse than target species inside and outside the MPAs. Low diversity of target fish could be an indication of overfishing. This could also suggest that poaching was prevalent since target species are those that are usually caught by fishers and commonly sold in the local market for food consumption.

Table 4. Fish Species Diversity Category

Fish Species Diversity Category (no. of species/1000m^2)						
MPA	Target		Non-target		Target and Non-target	
	Inside	Outside	Inside	Outside	Inside	Outside
Casay	36 Poor	No data	85 High	No data	121 Very high	No data
Cawayan	48 Moderate	27 Poor	72 Moderate	65 Moderate	120 Very high	92 High
Daan-Lungsod-Guiwang	52 Moderate	18 Very Poor	87 High	60 Moderate	139 Very high	78 High
North Granada	56 Moderate	22 Very Poor	80 High	49 Moderate	136 Very high	71 Moderate
Sta. Cruz	39 Poor	30 Poor	74 Moderate	59 Moderate	113 Very high	89 High

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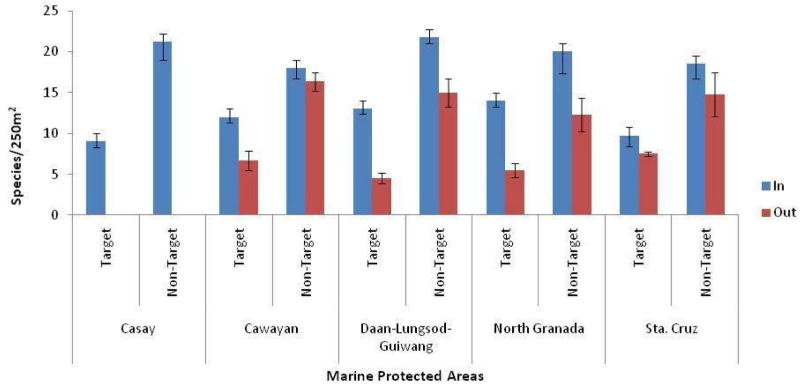

Figure 2. Mean Fish Species Richness (species/250m^2) of the 5 MPA's (± standard error, n=4 for Casay, Daan-Lungsod Guiwang, North Granada, Sta. Cruz, n=6 for Cawayan)

Fish Density

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In terms of target species, the inside and outside density showed no significant difference ($t(0.22) = 0.8365$, $p>.05$). Similarly, non-target species inside and outside also showed non-significant difference ($t(1.26) = 0.2542$, $p>.05$). This is an indication that densities of target fish inside and outside the MPAs were more or less of the same condition. This observation also holds true for non-target species both inside and outside the MPAs.

Based on Hilomen's classification, the density of target fish was poor to moderate while non-target moderate to high inside the MPAs (Table 5). Density of all fish was moderate to high inside the MPAs but these fishes were composed mostly of non-target species.

Higher density of non-target fish species were observed compared to target fishes as shown in Figure 3. Due to the high market value of target fish, they are often collected by fishermen depleting their numbers. Proliferation of non-target fish species usually occurs since they are not preferred as food.

These results suggest that these were all exposed to fishing activities and MPAs are being poached since the inside and outside fish densities showed non-significant difference at all.

The dominant target species density came from family Scaridae and Caesonidae; while the dominant fish density of non-target species came from Pomacentridae and Serranidae. Higher abundance of damselfish (Pomacentridae) observed were probably due to the lack of top predators which decline first following intense fishing pressure (Russ and Alcala, 1998).

Table 5. Fish Species Density Category

Fish Species Density Category (no. of fish/1000m^2)						
MPA	Target		Non-target		Target and Non-target	
	Inside	Outside	Inside	Outside	Inside	Outside

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Casay	878 Moderate	No data	3135 High	No data	4,013 High	No data
Cawayan	422 Poor	213 Poor	1281 Moderate	1474 Moderate	1,703 Moderate	1,687 Moderate
Daan-Lungsod-Guiwang	212 Poor	163 Very Poor	2715 High	1771 Moderate	2,927 High	1,934 Moderate
North Granada	374 Poor	643 Poor	2276 High	1693 Moderate	2,650 High	2,336 High
Sta. Cruz	436 Poor	322 Poor	1881 Moderate	1647 Moderate	2,317 High	1,969 Moderate

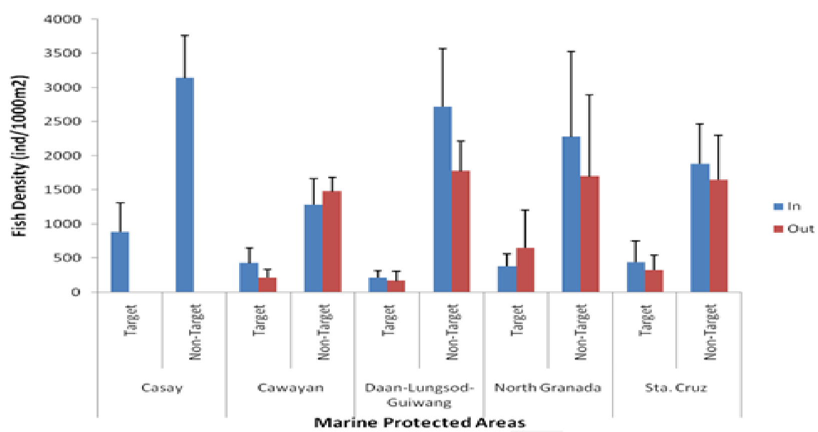

Figure 3. Mean Fish Density (ind./1,000m^2) of the 5 MPA's (+ standard error, n=4 for Casay, Daan-Lungsod Guiwang, North Granada, Sta. Cruz, n=6 for Cawayan)

Fish Biomass

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The mean fish biomass (kg/1000m^2) of target species inside the four (4) marine MPAs (excluding Casay) showed significant difference ($t(2.98) = 0.0246$, $p<.05$) while non-target species inside and outside showed non-significant difference ($t(2.29) = 0.0622$, $p<.05$). Based on the results, the mean biomass of target fishes inside the MPAs is higher than the outside (Figure 4). On the other hand, biomass of non-target species inside and outside the MPAs did not vary much based on t-test result.

Based on Hilomen's classification, the biomass of target and non-target fish were categorized as high to very high inside the MPAs (Table 6). Mean biomass of both target and non-target fish were categorized as very high inside the MPAs. Target fish contributed most of the fish biomass.

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It has been observed that fishes were larger inside the MPAs and were contributed much by target fish species of family Scaridae and Caesonidae. However, in Daan-Lungsod Guiwang MPA, the fish biomass is greatly contributed by non-target fish both inside and outside of its MPA.

There is no difference in the fish biomass of non-target species inside and outside the MPAs. Non-target fish observed belongs to family Chaetodontidae, Labridae and Pomacentridae. Since the non-target species cannot be utilized as food, they are left undisturbed inside and outside the MPAs. Proliferation of non-target fish species may be an indication of heavy fishing pressure occurring in the area.

Table 6. Fish Species Biomass Category

Fish Species Biomass Category (MT/km^2)						
MPA	Target		Non-target		Target and Non-target	
	Inside	Outside	Inside	Outside	Inside	Outside
Casay	75 Very high	No data	31 High	No data	106 Very high	No data
Cawayan	46 Very high	19 Medium	23 High	11 Medium	69 Very high	30 High
Daan-Lungsod Guiwang	42 Very high	11 Medium	72 Very High	15 Medium	114 Very high	26 High
North Granada	34 High	25 High	28 High	17 Medium	62 Very high	42 Very High
Sta. Cruz	72 Very high	31 High	37 High	15 Medium	109 Very high	46 Very High

In general, fish diversity, density and biomass are obvious parameters that could identify whether a certain MPA is strictly protected or not. Results showed that fish species are more diverse inside the MPAs and higher biomass of target fish are found inside the MPAs. This supports the idea that long-term protection of MPAs could really increase fish diversity, density and biomass.

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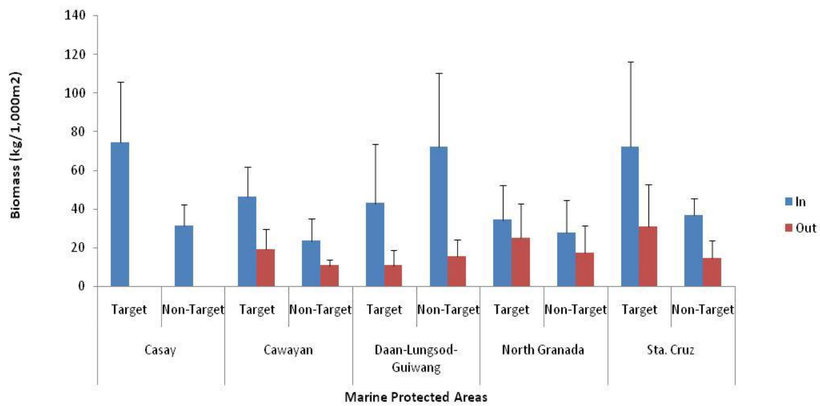

Figure 4. Mean Biomass (kg/1000m2) of the Five (5) MPA's (+ standard error, n=4 for Casay, Daan-Lungsod Guiwang, North Granada, Sta. Cruz, n=6 for Cawayan)

Table 7. List of Target and Non-Target Species

FAMILY	SPECIES	Argao Inside	Argao Outside	Dalaguete Inside	Dalaguete Outside	Alcoy Inside	Alcoy Outside	Boljoon Inside	Boljoon Outside	Ronda Inside	Ronda Outside
Acanthuridae	*Ctenochaetus tominiensis**	X		X X	X	X X	X	X X	X X	X	X
	*Acanthurus pyroferus**	X				X		X		X	
	*Naso hexacanthus**	X						X			
	*Acanthurus japonicus**	X									
	Zebrasoma scopas	X				X		X			
	*Ctenochaetus striatus**	X		X		X	X	X		X	X
	*Paracanthurus hepatus**					X					
	*Acanthurus lineatus**							X			
	*Naso vlamingii**								X		
	*Ctenochitus japonicus**									X	X
Apogonidae	*Apogon compressus**	X						X	X	X	X
	Sphaeramia nematoptera				X						
	Cheilodipterus quinquelineatus					X		X	X		
Balistidae	*Balistapus undulatus**	X		X	X	X	X	X		X	X
	*Balistoides viridesceus**					X		X			
	*Sufflamen chrysopterus**							X			
	*Balistidae sp.**									X	X
Blennidae	*Ecsenius midas*									X	X
Caesionidae	*Pterocaesio tile**	X						X			
	*Caesio cunning**							X			

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	*Caesio teres**	X		X	X			X		X	X
	*Caesio caerulaurea**	X				X	X				
	*Pterocaesio pisang**	X		X	X		X	X	X	X	X
Carangidae	*Caranx melampygus**								X		
Centricidae	*Centriscus scutatus*								X		
Chaetodontidae	*Chaetodon oxycephalus*	X		X		X		X	X	X	
	Heniochus varius	X		X			X	X	X	X	
	Chaetodon baronessa	X		X	X		X	X	X	X	X

FAMILY	SPECIES	Argao		Dalaguete		Alcoy		Boljoon		Ronda	
		Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
Chaetodontidae	*Chaetodon octofasciatus*	X		X	X	X		X	X	X	
	Heniochus chrysostomus	X				X		X			
	Chelmon rostratus			X				X	X	X	
	Chaetodon auriga			X						X	
	Chaetodon selene							X			
	Chaetodon octofasciatus										X
	Heniochus varius										X
Ephippidae	*Platax tiera**					X					
	Platax orbicularis					X					
Fistularidae	*Fistularia commersonii*				X						
	Fistularia sp.					X					
Gobiidae	*Cryptocentrus sp*			X							
	Amblygobius phalaena						X				
Haemulidae	*Plectorhinchus lineatus**					X					
Holocentridae	*Myripristis murdjan**	X		X							
	*Myripristis hexagona**					X		X			
Labridae	*Cheilinus fasciatus**	X		X	X			X			X
	Cirrhilabrus cyanopleura	X		X	X	X	X	X	X	X	X
	Labroides dimidiatus	X		X	X		X	X	X	X	
	Labroides pectoralis	X									
	Thalassoma hardwicke	X			X		X	X		X	X
	Oxycheilinus digrammus	X		X	X	X	X	X			
	Oxycheilinus celebicus	X		X	X	X		X			X
	Thalassoma lunare	X		X	X		X	X	X	X	X
	Bodianus mesothorax	X		X	X	X	X	X	X	X	
	Halichoeres hortulanus			X						X	

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	Coris batuensis				X		X				
	Choerodon sp.					X					
	Coris caudimacula					X	X				
	Choerodon graphicus						X				
	*Choerodon fasciatus**	X		X							
	Labridae sp.						X				

FAMILY	SPECIES	Argao		Dalaguete		Alcoy		Boljoon		Ronda	
		Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
Labridae	*Halichoeres papilionaceus*									X	X
	Gomphosus varius										X
Letrinidae	*Letrinus harak**							X			
Lutjanidae	*Lutjanus decussatus**	X		X	X	X	X	X	X	X	X
	*Macolor macularis**							X	X		
	*Lutjanus fulvus**							X			
	*Lutjanus dicussatus**							X		X	
	*Lutjanus ehrenbergii**							X	X	X	
	*Lutjanus biguttatus**									X	
Mullidae	*Parupeneus barberinoides**	X		X		X		X	X	X	
	*Parupeneus barberinus**	X		X	X	X	X	X	X	X	X
	*Parupeneus bifasciatus**	X						X	X		X
	*Parupeneus macronemua**						X				
Nemipteridae	*Scolopsis bilineatus**	X		X		X	X	X	X	X	X
	*Scolopsis ciliatus**			X	X					X	X
	*Upeneus tragula**				X		X				
Pinguipedae	*Paarapercis clathrata*							X			
Pomacanthidae	*Chaetodontoplus mesoleucos*	X			X	X		X			
	Genicanthus lamarck	X									
	Centropyge vroliki	X					X	X	X		
Pomacanthidae	*Pygoplites diacanthus*	X		X	X	X	X	X	X	X	X
	Centropyge bicolor			X		X					
Pomacentridae	*Amblyglyphidodon leucogaster*	X		X	X	X		X	X	X	X
	Abudefduf sexfasciatus	X				X	X			X	
	Neoglyphidodon melas	X		X	X	X	X	X	X	X	X
	Chrysiptera cyanea	X		X	X	X	X	X	X	X	X
	Chromis weberi	X				X	X	X	X		X
	Chromis retrofasciata	X		X	X	X		X		X	X
	Chromis analis	X								X	

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	Dascyllus trimaculatus	X		X	X			X	X	X	X
	Dascyllus reticulatus	X		X	X	X	X	X	X	X	X

FAMILY	SPECIES	Argao		Dalaguete		Alcoy		Boljoon		Ronda	
		Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
Pomacentridae	*Pomacentrus alexanderae*	X		X	X	X	X	X	X	X	X
	Pomacentrus molluccensis	X		X	X	X	X	X			
	Chromis amboinensis	X		X	X		X	X		X	X
	Abudefduf notatus	X				X					
	Chromis caudalis	X									
	Chromis flavomaculata	X						X		X	X
	Pomacentrus brachialis	X							X	X	X
	Pomacentrus littoralis	X									
	Pomacentrus moluccensis	X									
	Dascyllus aruanus			X	X		X	X	X	X	X
	Amphiprion clarkii			X				X		X	
	Chromis viridis					X	X	X			
	Acanthochromis polycantha					X	X				
	Amphiprion chrysopterus					X	X		X		
	Chrysiptera parasema					X	X				
	Dascyllus melanurus					X	X	X	X	X	X
	Pomacentrus lepidogenys					X	X				
	Chetloprion labiatus						X				
	Dascyllus sp.						X				
Pomacentridae	*Abudefduf vaigiensis*							X			
	Dascyllus auripinninis							X	X		
	Dischistodus fasciatus							X			
	Amblyglyphidodon aureus								X		
	Chromis alpha									X	X
	Pomacentrus stigma									X	X
	Stegastes aureus									X	X
Scaridae	*Scarus dimidiatus**	X		X		X		X		X	
	Scarus ghobban*	X		X	X	X	X	X	X	X	X
	Chlorurus bleekeri*	X		X	X	X	X	X	X	X	X
	Cetoscarus bicolor*			X	X	X	X			X	X
	Scarus niger*					X		X			

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	Scarus oviceps*									X	X

FAMILY	SPECIES	Argao		Dalaguete		Alcoy		Boljoon		Ronda	
		Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
Scorpionidae	Pterois volitans									X	
Serranidae	Cephalopholis boenak*	X		X	X			X		X	X
	Diploprion bifasciatum	X		X	X	X				X	X
	Pseudanthias hutchtii	X			X	X	X	X	X	X	X
	Cephalopholis microprion*			X	X		X	X	X	X	
	Epinephelus ongus*					X					
	Pseudanthias pascalus	X				X	X	X	X	X	X
	Epinephelus socialis*							X			
	Cephalopolis argus*							X			
	Pomacanthus navarchus								X		
	Pseudanthias squamipinnis	X								X	X
	Pseudanthias tuka	X						X	X	X	X
	Pseudanthias randalli							X	X		
Siganidae	Siganus vulpinus*	X		X		X		X			
Siganidae	Siganus guttatus*				X						X
	Siganus canaliculatus*				X		X				
	Siganus virgatus*							X			
Sphyraenida	Sphyraena flavicauda*						X			X	
Synodontidae	Synodus variegatus			X				X			
Tetraodontidae	Arothron mappa	X		X							
	Canthigaster valentini	X			X		X				X
	Arothron nigropunctatus	X				X	X	X	X		
	Canthigaster papua					X		X			
Zanclidae	Zanclus cornutus	X		X	X	X	X	X	X	X	X

CONCLUSION

Based on the results of the survey, Sta. Cruz which has been non-functional for three (3) years (2007-2010) and was re-established in 2011 by a new set of management, showed a comparable or better results compared to the four (4) MPAs that have been functional/operational for about 6-11 years to date. This is may be an indication that the latter may all be open to heavy fishing pressure.

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Generally, marine protected areas in the study sites have played an important role in fishery conservation but needs long-term protection and should be well-managed to improve fish population in terms of fish diversity, density and biomass.

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